

**Field guide to exhumed paleochannels near Green River, Utah:  
Terrestrial analogs for sinuous ridges on Mars**

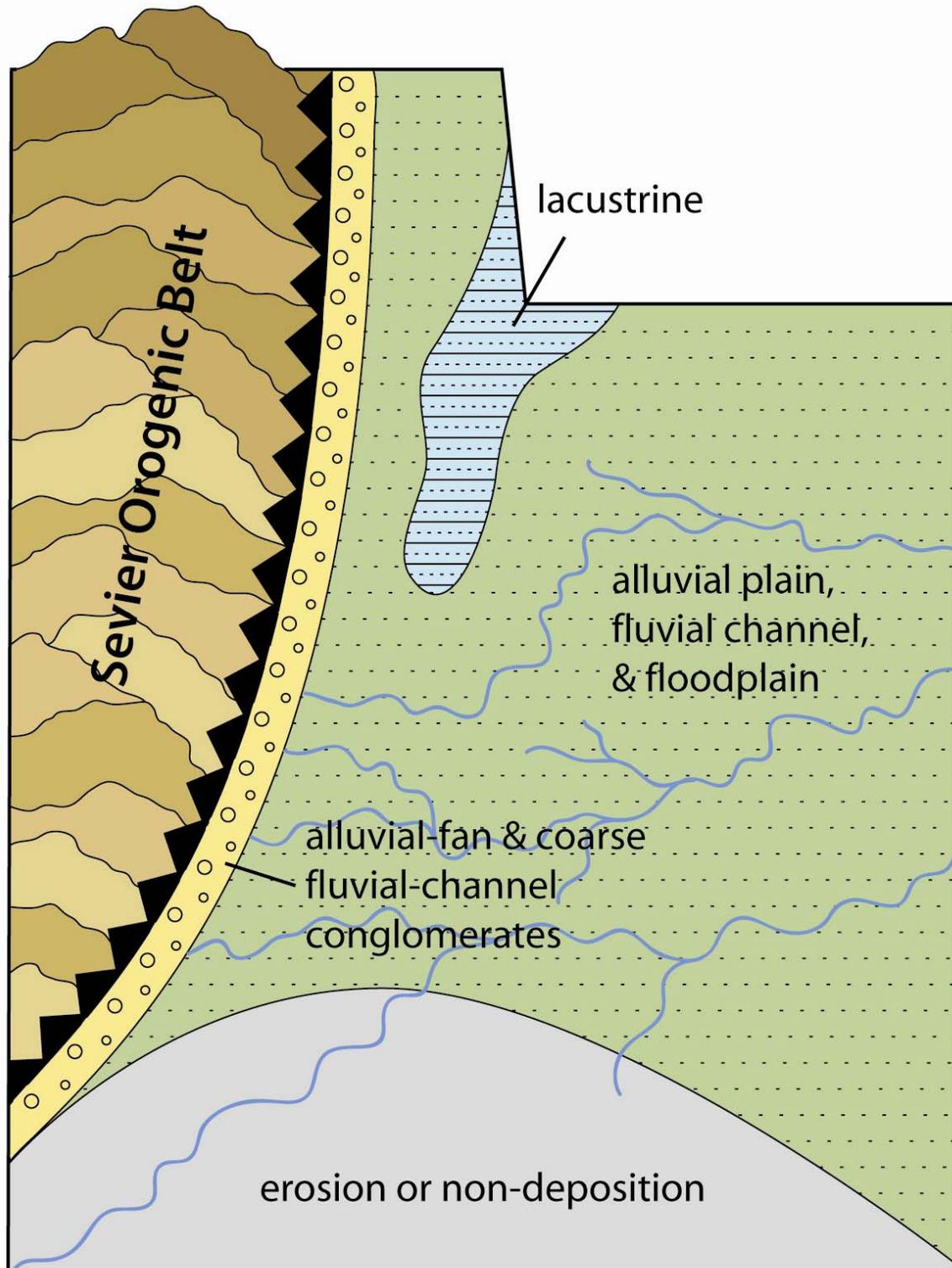
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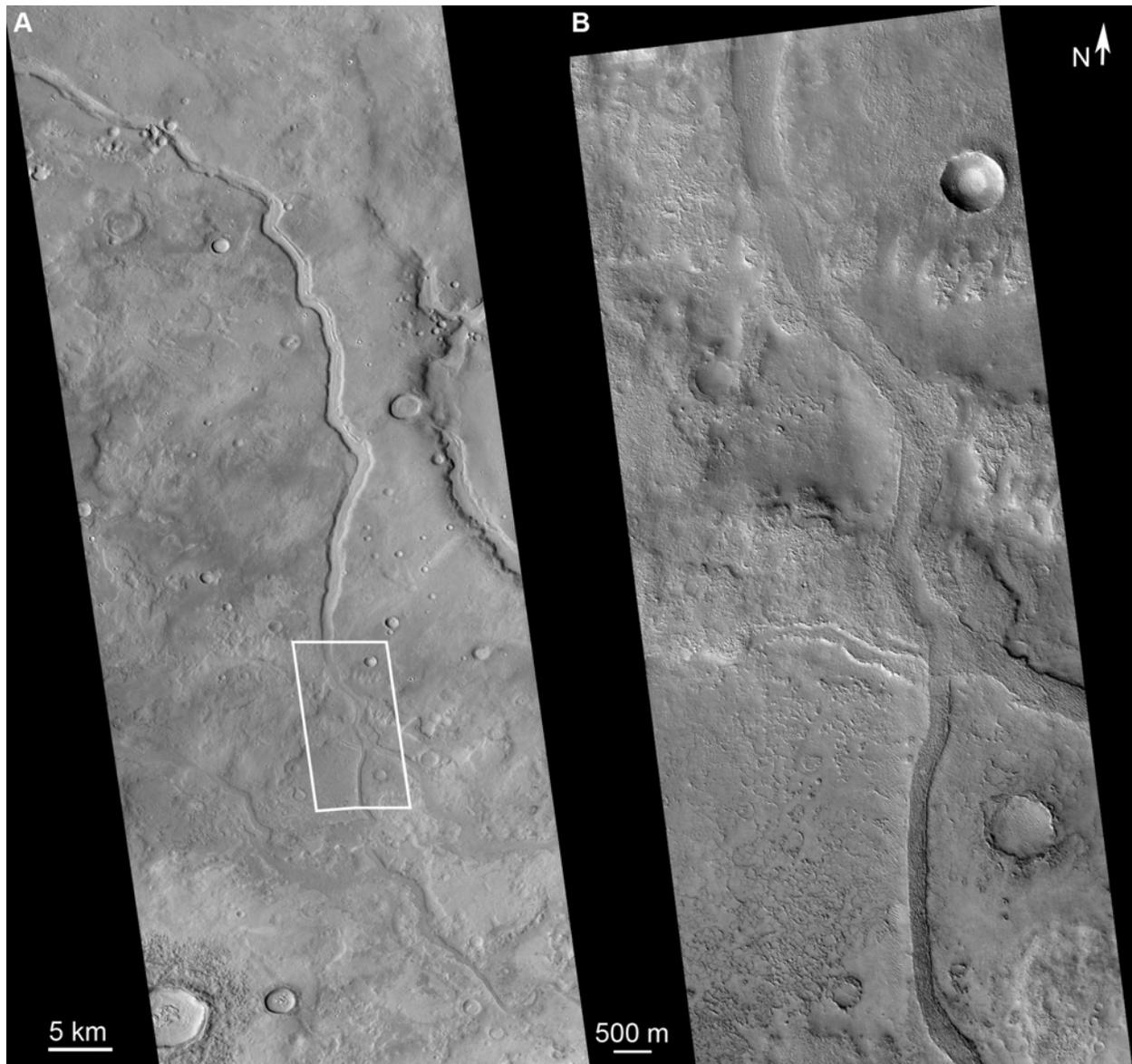
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**Figure DR1.** Paleogeographic map of Utah during Ruby Ranch time (Aptian to middle Albian) with Sevier orogenic belt in western Utah and various fluvial depositional environments present in east-central Utah (Figure from Williams et al., 2007, modified from Elder and Kirkland, 1993; Kirkland et al., 1998).



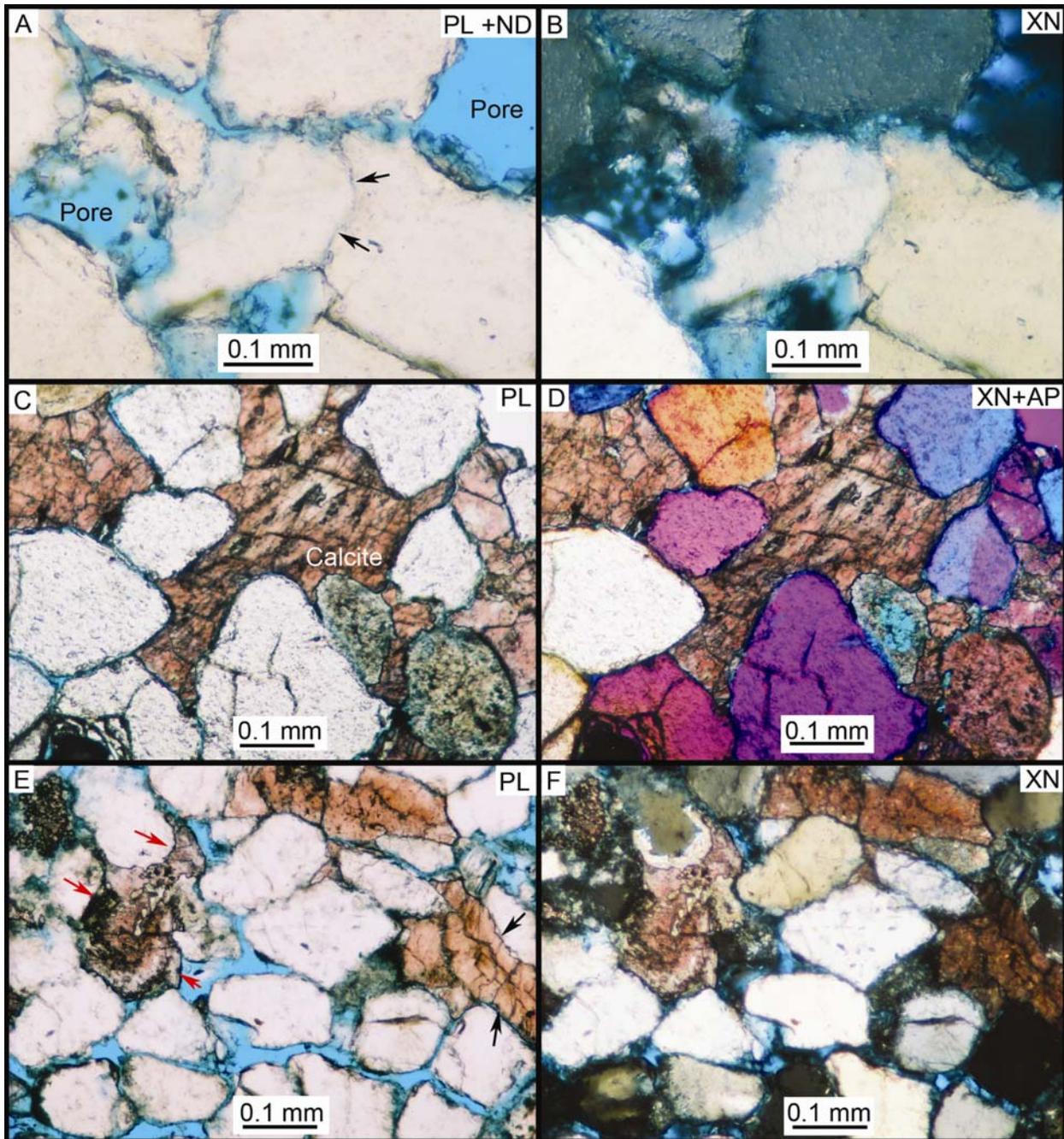
**Figure DR2.** View to the east of Derr's (1974) inverted channel 2 in the Brushy Basin Member of the Morrison Formation and location of stop 1. See Figure 8 for vantage point 'P' where picture was taken. Ridge along the skyline is the Ferroan Sandstone Member in the lower part of the Mancos Shale. Note truck for scale. Photo by T. Chidsey.



**Figure DR3.** A) Negative relief valley network (top of image) transitions to a low relief plateau (sinuous ridge at bottom) near  $32^{\circ}$  N,  $314^{\circ}$  W in Arabia Terra. White box marks location of panel B. Illumination from the lower left in this subsense of CTX image P15\_006990\_2127. B) Subscene of HiRISE image PSP\_005355\_2125 showing transition zone. Illumination is from the left (note impact crater at upper right in panel B). Image modified from original NASA/JPL/University of Arizona.



**Figure DR4.** A) View to the west from a nearby hill where two low-relief ( $<2$  m) inverted channels are marked by black and white arrows. See Figure 8 for vantage point 'P' where the picture was taken. The San Rafael Swell is in the background. Width of scene at the location of the black arrows is  $\sim 0.5$  km. Photo by T. Chidsey. B) Ground-based photo of same site shows that the surface expression of these inverted channels (marked by white and black arrows) is very subtle. Photo by R. Williams.



**Figure DR5.** Photomicrographs from samples of cemented channel materials in the Brushy Basin Member of the Morrison Formation (Figure 8, stop 2). Examples A-D are from site L and examples E-F are from site M. A) Low-resolution view of quartz sandstone with extensive calcite cement. 50X. B) Interpenetrating quartz grain contacts (black arrows) provide evidence of burial. 250X. C) Sparry calcite cement is pink due to Alizarin Red-S staining. 200X. D) Same view with XN+AP. 200X E) Adjacent pores have different composition: calcite (black arrows) and ferroan calcite (red arrows). Dissolution pores (blue voids) are also present. 200X. F) Same view with XN. Note pressure-solution grain contacts. 200X.

For all photomicrographs, the following key is used:

PL = Plain Light; XN = Crossed Nicols; AP = Gypsum Accessory Plate; ND = Neutral Density filter.



**Figure DR6.** Several examples of outcrop exposures at the base of paleochannels in the Ruby Ranch Member. A) In channel D, muddy deposits are protected by overlying channel deposits, forming an overhang in the picture. Green and yellow-brown mudstone subjacent to the channel base formed in a reducing environment at the channel-floodplain interface. Photo by R. Williams. B) In places, there are large (~50 cm diameter) limestone rip-up clasts, likely lacustrine deposits that were reworked during high flow events. This example is from channel A. Photo by J. Zimelman. C) Elsewhere the base of channel D is marked by a basal conglomerate with pedogenic carbonate nodules up to 10 cm in diameter; a similar basal conglomerate is observed elsewhere in the Cedar Mountain Formation to the north (Currie, 1998). Photo by R. Williams.

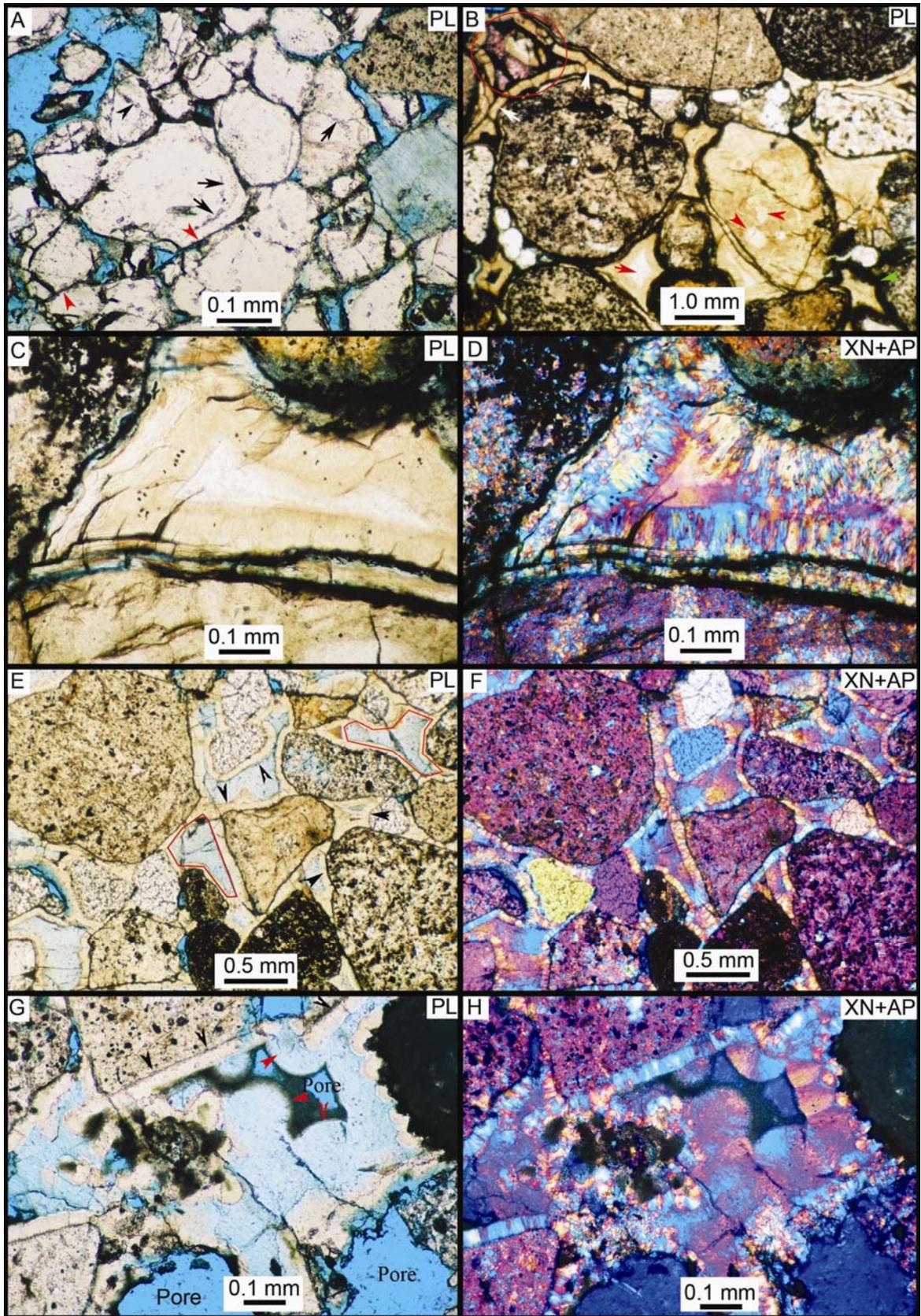


Figure DR7.

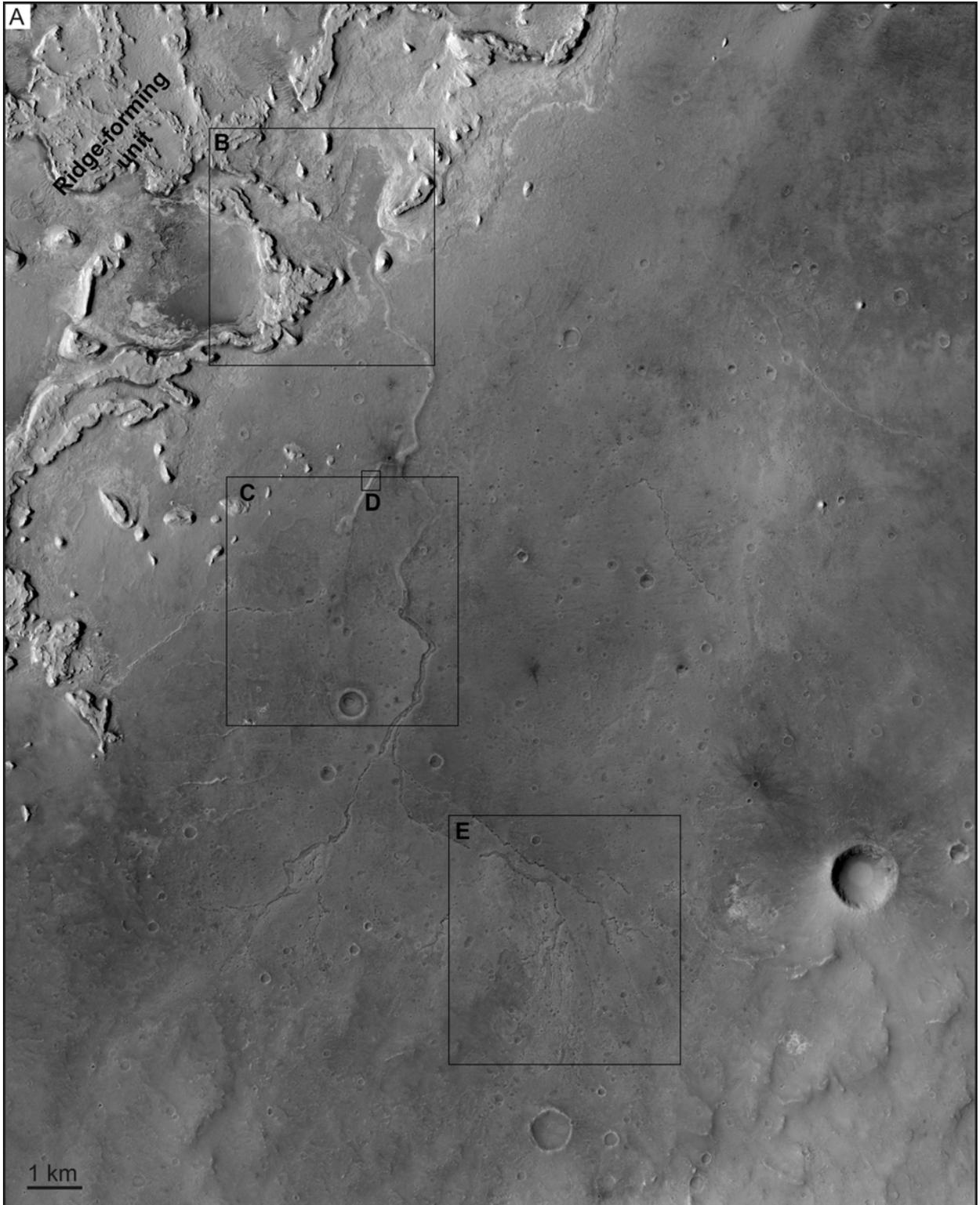
**Figure DR7.** Photomicrographs from samples of cemented channel materials in the Cedar Mountain Formation. Sample locations are marked on Figure 10B with example A from site E, examples B-D from site F and examples E-H from site G. A) Quartz-cemented coarse sandstone with secondary porosity (blue voids). Dust lines (arrows) demarcate quartz grain and silica overgrowth cement boundary. Linear grain contacts (red arrows) are evidence for pressure solution modification and indicate the specimen was largely uncemented prior to burial. Plain light (PL) 160X. B) Sandstone with multiple stages of silica cement formed under near-surface conditions: isopachous silica cements encircling grains (white arrows) form in phreatic pores, pore-filling silica cement is dense and brownish (green arrow), and third-generation crystalline cement with white core (red arrows). Alizarin Red-S staining highlights minor, late-stage calcite cement (red circle). PL 18.5X. C) Pore-filling siliceous cement. PL 160X. D) Same view as previous with crossed Nichols (XN) and gypsum accessory plate (AP) which highlights the fibrous character of the chalcedony cement. 160X. E) Isopachous silica cement (black arrows) encircles grains. Light blue color (from blue impregnated epoxy; red outline) indicates the microporous nature of the pore-filling silica cement. 40X. F) Same view as previous with XN+AP. Fibrous character of chalcedony cement is evident. 40X. G) Isopachous siliceous cement (black arrows) and secondary botryoidal, microporous siliceous cements (red arrows) in pore centers. 130X. H) Same view as previous with XN+AP shows the radiating fiber of the botryoidal cement. 130X.

For all photomicrographs, the following key is used:

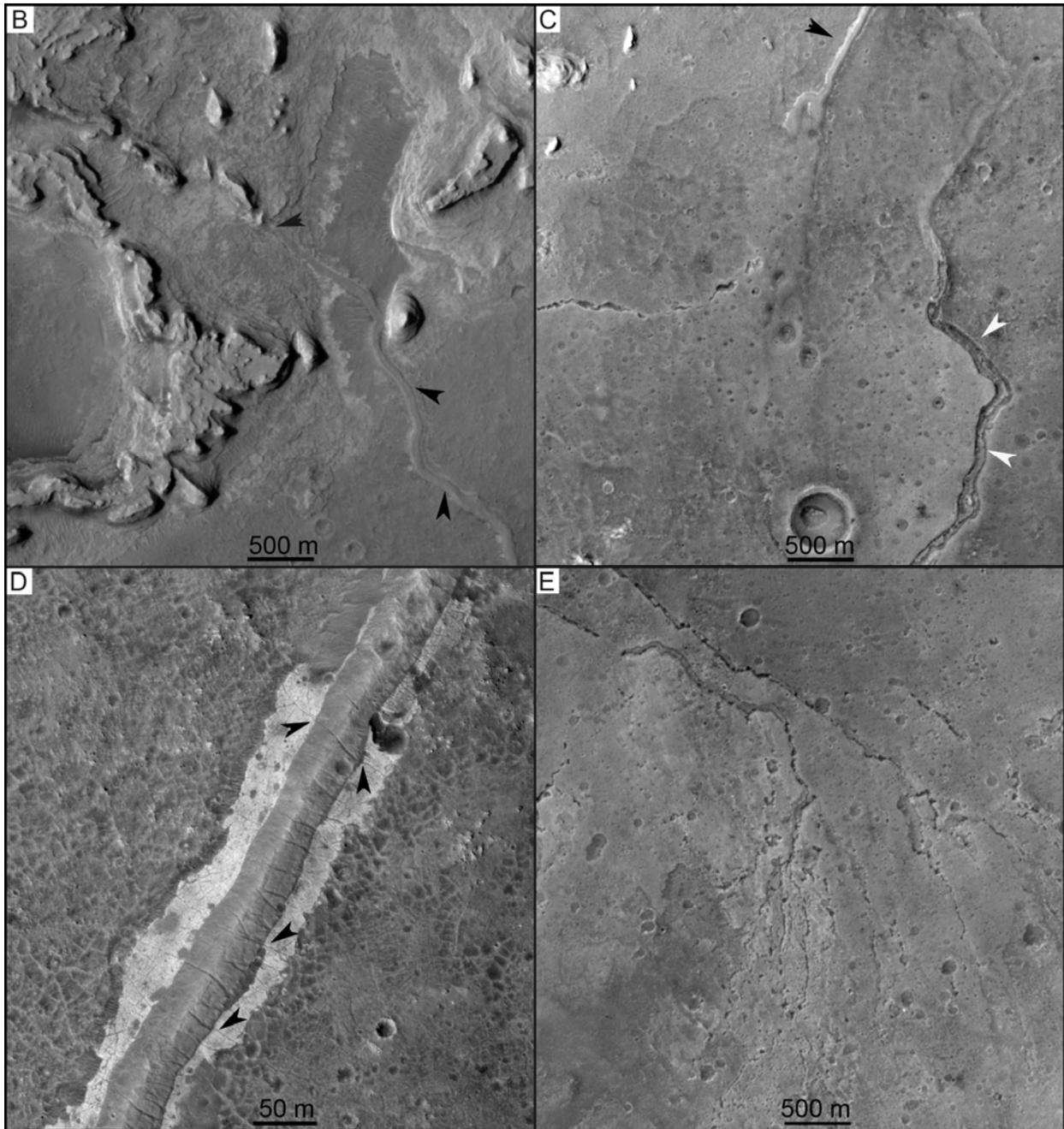
PL = Plain Light; XN = Crossed Nicols; AP = Gypsum Accessory Plate; ND = Neutral Density filter.



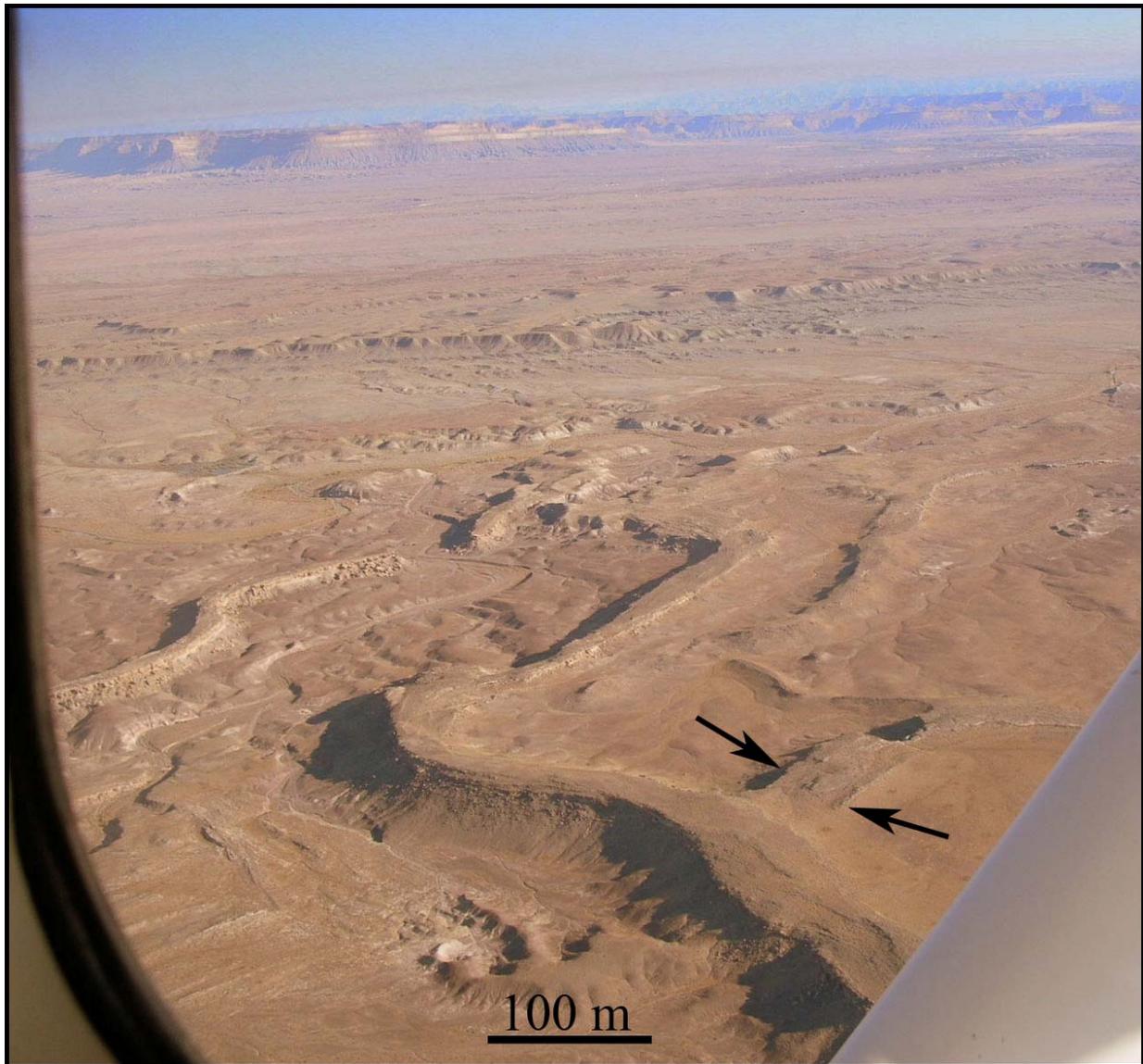
**Figure DR8.** Oblique aerial photograph to the southeast of a sinuous section of channel A in the Cedar Mountain Formation. Water gap marked by black arrow at top right. Older channels (white arrow at center bottom) beneath the main trunk channel are preserved only on the north side. Image width in foreground is ~1.8 km. Illumination is from the upper left. Photo by R. Williams.



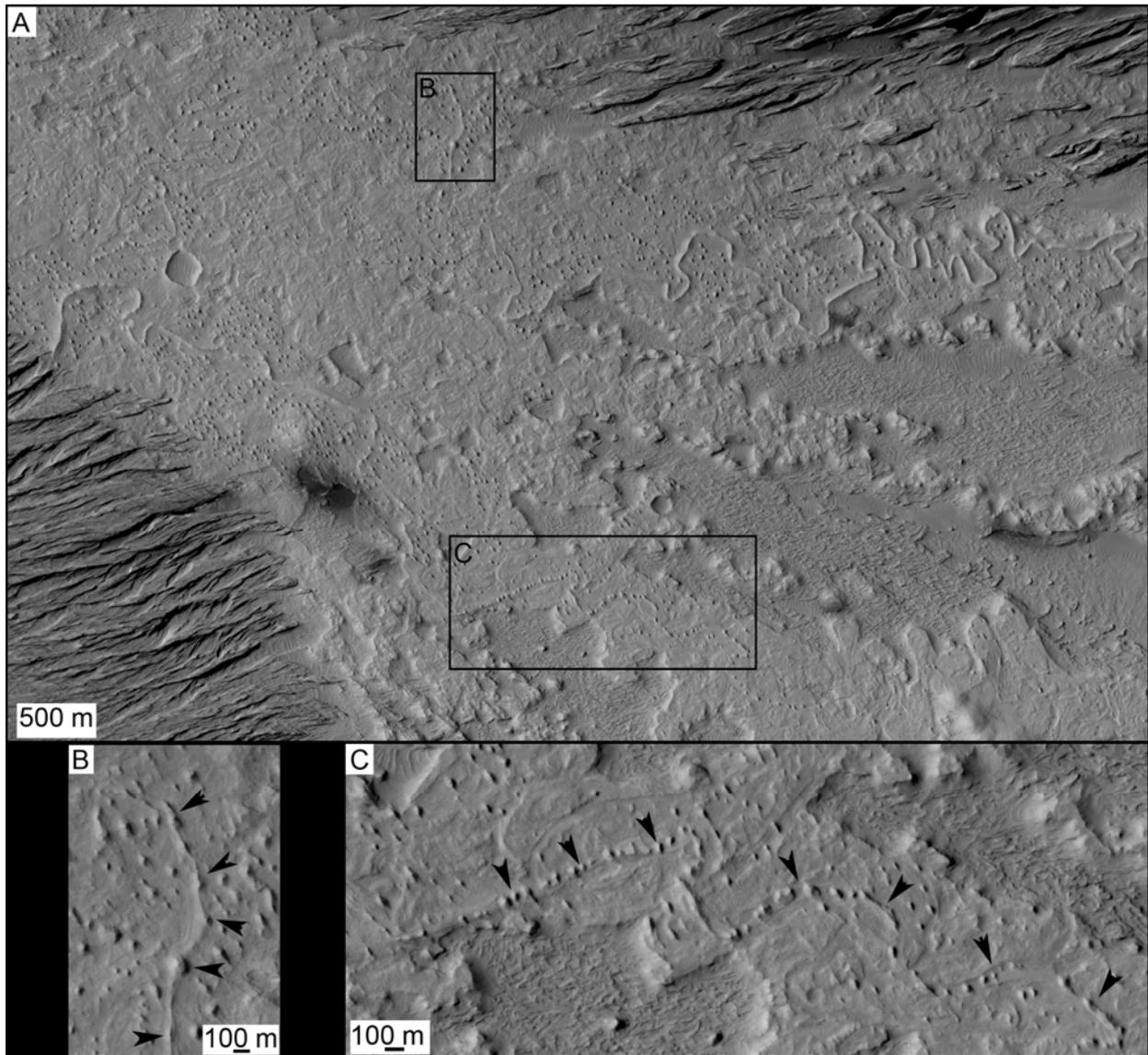
**Figure DR9A.**



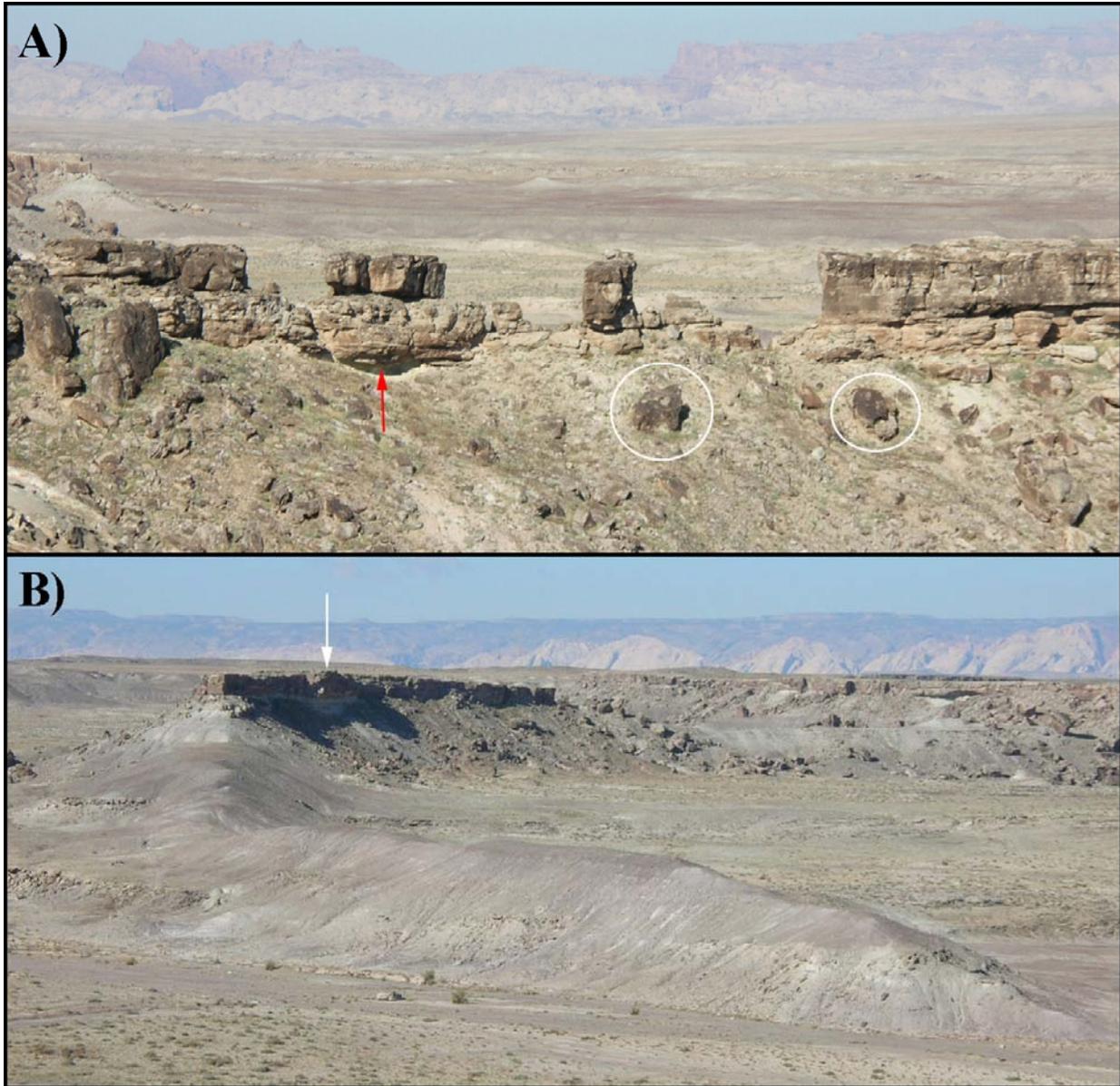
**Figure DR9.** (A) Branching landform in Meridiani Planum that exhibits variations in preservation style from positive to negative relief. Black boxes in A are enlargement of subscenes from panel A are presented in panels B-E. Northern portion of system (B), presumably the downstream section, is buried beneath rock layers (black arrow). The landform transitions from positive relief (low-relief ridge marked by black arrow) to negative relief trough (white arrows in C) that has a medial ridge in places. The southern portion of the landform is marked by a series of aligned pits that trace out the branching pattern (E). At higher resolution (D), the stratigraphic relationship is evident with the low-relief, light-toned ridge (the inverted channel) capped by a narrow band of the former overburden. The cracked pattern on the light-toned ridge and superposing material (cracks are sometimes traverse across the two materials, marked by black arrows) differ in size and configuration from the polygonal pattern on the surrounding plains. Panels A-C and E are subframes of CTX image P03\_002390\_1840 near 4.6° N, 1.3° W. Panel D is subframe of HiRISE PSP\_004091\_1845. Illumination is from left for all images.



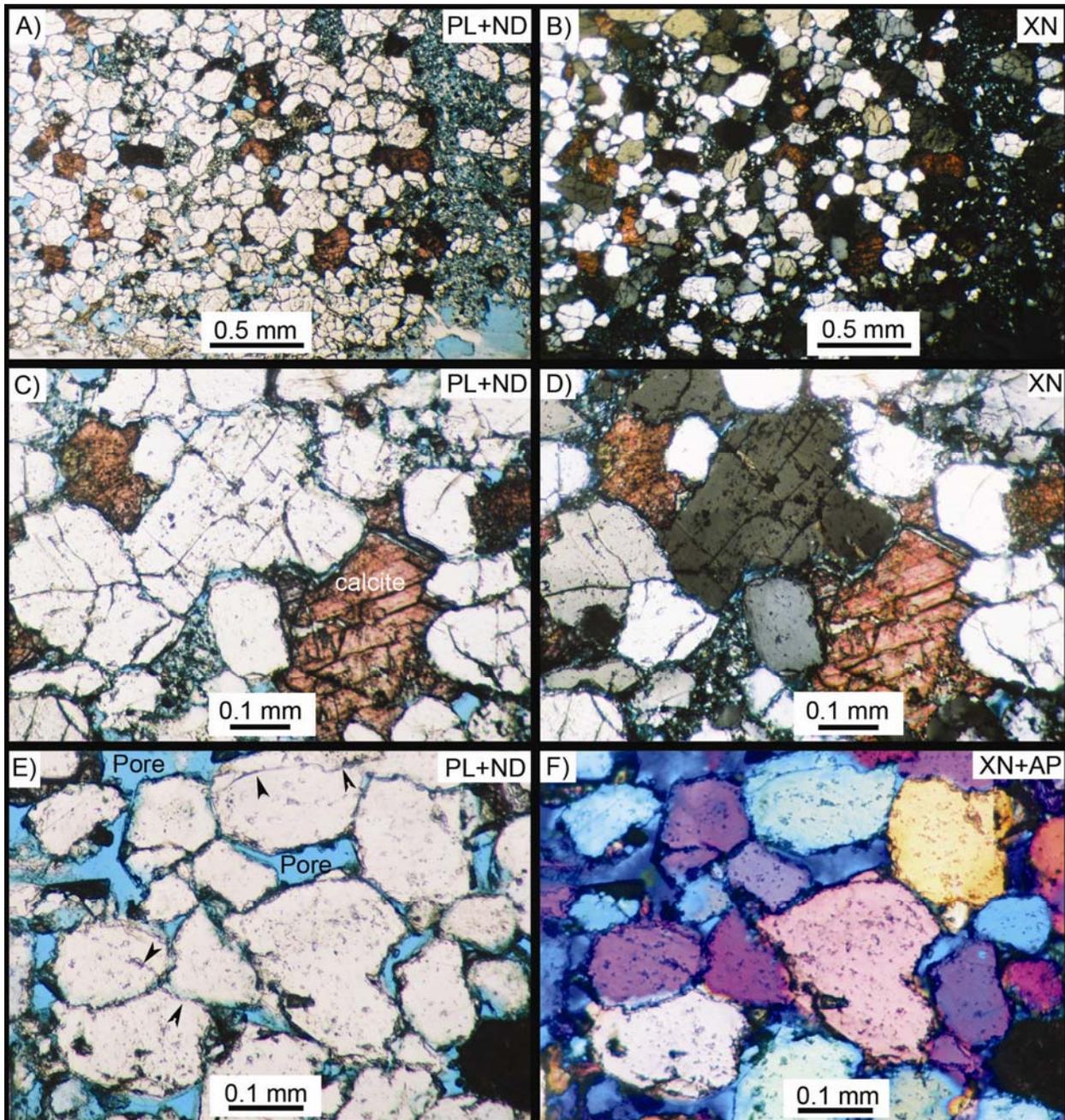
**Figure DR10.** Oblique aerial photograph of two channel segments in the Cedar Mountain Formation looking northward, at the location near the labels F and G in Figure 10. The apparent bifurcation marked by black arrows is actually two segments at two different topographic and stratigraphic levels. The inverted paleochannel segment from top to bottom (north to south, segment D) in image is stratigraphically higher than the paleochannel segment that extends to the right (westernmost section of segment B). Scale bar is for image foreground. The Late Cretaceous Book Cliffs (e.g. Young, 1955), which form the northern rim of the Colorado Plateau in eastern Utah, are visible in the background. Photo by R. Williams.



**Figure DR11.** A) Sinuous ridges in the Aeolis/Zephyria Plana region immediately east of the location in Figure 6. Black boxes are approximate regions enlarged in panels B and C, which show areas where eolian erosion has modified former sinuous ridges into aligned knobs and mesas (black arrows). Subframe of CTX image P03\_002081\_1751 is located near 5° S, 205° W. Illumination is from lower left.



**Figure DR12.** A) Examples of degradation along sections of inverted paleochannels in the Ruby Ranch Member of the Cedar Mountain Formation. Erosion exploits the joints and faults in the paleochannels, producing blocks of cemented channel sediments. Blocks that have been transported downslope by mass wasting are marked by white circles. Differential erosion is also evident, with the underlying mudstone preferentially removed from beneath the more resistant paleochannels caprock; this undermining produces alcoves (red arrow). B) Cemented fluvial sediments form a cap stone (white arrow). Where the capstone has been removed, the underlying mudstone still marks the original flow path (in this case curving around to the lower right in the image).



**Figure DR13.** Photomicrographs from samples of cemented channel materials in the Salt Wash Member of the Morrison Formation (stop 7; Figure 12). A) Quartz sandstone with silica overgrowth cements and minor calcite (red due to Alizarin Red-S stain) cement in plain light with neutral density filter. 50X. B) Same view as in previous figure with XN. 50X C) Sparry calcite (red) and silica cement around detrital quartz grains. 160X. D) Same view as in previous figure. 160X. E) Close-up view of dust lines (arrows) separating grains from silica cement. 200X. F) Same view as in previous figure. Optical continuity between grain and cement is evident under XN. 200X.

For all photomicrographs, the following key is used:

PL = Plain Light; XN = Crossed Nicols; AP = Gypsum Accessory Plate; ND = Neutral Density filter.



**Figure DR14.** View of the contact between cemented fluvial deposits and underlying red floodplain materials within the Salt Wash Member of the Morrison Formation. The capstone margin is near vertical and cut by fractures. Approximate outcrop thickness is 2.5 m. Photo by R. Williams.

**References:**

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